

WHAT IS CLAIMED IS:

1                    1.        A process for producing an acetyl anhydride comprising contacting  
2 methane and carbon dioxide in an anhydrous environment in the presence of effective  
3 amounts of a transition metal catalyst and a reaction promoter, and an acid anhydride  
4 compound, and optionally an acid, to produce a product comprising the acetyl anhydride.

1                    2.        A process according to claim 1 further comprising:

2                    (b) contacting the product comprising the acetyl anhydride with water.

1                    3.        A process according to claim 2 further comprising recovering acetic  
2 acid from step (b).

1                    4.        A process according to claim 1 further comprising:

2                    (b) contacting the product comprising the acetyl anhydride with an alcohol.

1                    5.        A process according to claim 4 further comprising recovering an  
2 acetate ester from the product of step (b).

1                    6.        A process according to claim 4 further comprising  
2 recovering acetic acid from the product of step (b).

1                    7.        A process according to claim 1 in which the catalyst is a vanadium-  
2 containing catalyst.

1                    8.        A process according to claim 7 in which the catalyst is selected from  
2 vanadium pentoxide, vanadium trioxide, sodium metavanadate, vanadium-containing  
3 heteropolyacid catalysts and vanadyl acetylacetonate.

1                    9.        A process according to claim 7 in which the catalyst is vanadyl  
2 acetylacetonate.

1                    10.      A process according to claim 1 in which the reaction promoter is  
2 selected from  $K_2S_2O_8$ ,  $K_4P_2O_8$ , calcium dioxide, urea-hydrogen peroxide, and m-  
3 chloroperbenzoic acid.

1                    11.     A process according to claim 10 in which the reaction promoter is  
2      $K_2S_2O_8$ .

1                    12     A process according to claim 1 in which the acid anhydride compound  
2     comprises sulfur trioxide, sulfur dioxide, trifluoroacetic acid anhydride,  
3     fluoromethanesulfonic acid anhydride, trifluoromethanesulfonic acid anhydride,  
4     fluorosulfonic acid anhydride, methanesulfonic acid anhydride, NO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, P<sub>2</sub>O<sub>5</sub>, SeO<sub>3</sub>,  
5     As<sub>2</sub>O<sub>5</sub>, TeO<sub>3</sub>, or B<sub>2</sub>O<sub>3</sub> or a mixture of two or more of the foregoing.

6                    13.     A process according to claim 1 in which the acid anhydride compound  
7     comprises trifluoroacetic acid anhydride.

1                    14.     A process according to claim 1 in which the acid anhydride compound  
2     comprises trifluoromethanesulfonic acid anhydride.

1                    15.     A process according to claim 1 in which the acid anhydride compound  
2     comprises sulfur trioxide.

3                    16.     A process according to claim 1 in which the acid anhydride compound  
4     comprises fuming sulfuric acid.

1                    17.     A process according to claim 1 in which an acid is present during the  
2     contacting.

1                    18.     A process according to claim 17 in which the acid comprises  
2     trifluoroacetic, methanesulfonic, fluorosulfonic, fluoromethanesulfonic,  
3     trifluoromethanesulfonic, sulfuric, fuming sulfuric, sulfurous, nitric, nitrous, phosphoric,  
4     phosphorous, superphosphoric, or boric acid, or a selenium- and tellurium-containing analog  
5     of the sulfur-containing acids, or a mixture of two or more of the foregoing.

1                    19.     A process according to claim 17 in which the acid comprises fuming  
2     sulfuric acid.

1                    20.     A process according to claim 17 in which the acid comprises  
2     trifluoroacetic acid.

- 1                    21        A process according to claim 17 in which the acid comprises  
2 trifluoromethanesulfonic acid.
- 1                    22.       A process according to claim 1 in which the acetyl anhydride  
2 comprises acetyl sulfate.
- 1                    23.       A process according to claim 1 in which the acetyl anhydride  
2 comprises acetyl trifluoroacetate.
- 1                    24.       A process according to claim 1 in which the acetyl anhydride  
2 comprises acetyl trifluoromethanesulfonate.
- 1                    25.       A process according to claim 1 in which the temperature is from about  
2 10 to about 200 °C.
- 1                    26.       A process according to claim 1 in which the temperature is from about  
2 60 to about 100 °C.
- 1                    27.       A process for producing acetic acid comprising:  
2                    (a) contacting methane and carbon dioxide in an anhydrous environment in the  
3 presence of effective amounts of a transition metal catalyst and a reaction promoter, and an  
4 acid anhydride compound, and optionally an acid, to produce a product comprising an acetyl  
5 anhydride; and  
6                    (b) contacting the product of step (a) with water.
- 1                    28.       A process according to claim 27, further comprising:  
2                    (c) recovering acetic acid from the product of step (b).
- 1                    29.       A process according to claim 27 in which the catalyst is a vanadium-  
2 containing catalyst.
- 1                    30.       A process according to claim 29 in which the catalyst is selected from  
2 vanadium pentoxide, vanadium trioxide, sodium metavanadate, vanadium-containing  
3 heteropolyacid catalysts and vanadyl acetylacetonate.

- 1                    31.     A process according to claim 29 in which the catalyst is vanadyl  
2     acetylacetonate.
- 1                    32.     A process according to claim 29 in which the reaction promoter is  
2     selected from  $K_2S_2O_8$ ,  $K_4P_2O_8$ , calcium dioxide, urea-hydrogen peroxide and m-  
3     chloroperbenzoic acid.
- 1                    33.     A process according to claim 32 in which the reaction promoter is  
2      $K_2S_2O_8$ .
- 1                    34.     A process according to claim 27 in which the acid anhydride  
2     compound comprises sulfur trioxide, sulfur dioxide, trifluoroacetic acid anhydride,  
3     trifluoromethanesulfonic acid anhydride, fluoromethanesulfonic acid anhydride,  
4     fluorosulfonic acid anhydride, methanesulfonic acid anhydride, NO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, P<sub>2</sub>O<sub>5</sub>, SeO<sub>3</sub>,  
5     As<sub>2</sub>O<sub>5</sub>, TeO<sub>3</sub>, or B<sub>2</sub>O<sub>3</sub>, or a mixture of two or more of the foregoing.
- 1                    35.     A process according to claim 27 in which the acid anhydride  
2     compound comprises trifluoroacetic acid anhydride.
- 1                    36.     A process according to claim 27 in which the acid anhydride  
2     compound comprises trifluoromethanesulfonic acid anhydride.
- 1                    37.     A process according to claim 27 in which the acid anhydride  
2     compound comprises sulfur trioxide.
- 3                    38.     A process according to claim 27 in which the acid anhydride  
4     compound comprises fuming sulfuric acid.
- 1                    39.     A process according to claim 27 in which an acid is present during the  
2     contacting.
- 1                    40.     A process according to claim 39 in which the acid comprises  
2     trifluoroacetic, fluorosulfonic, methanesulfonic, fluoromethanesulfonic,  
3     trifluoromethanesulfonic, sulfuric, fuming sulfuric, sulfurous, nitric, nitrous, phosphoric,  
4     phosphorous, superphosphoric or boric acid, or a selenium- or tellurium-containing analog of  
5     the sulfur-containing acids, or a mixture of two or more of the foregoing.

- 1                    41.     A process according to claim 39 in which the acid comprises fuming  
2     sulfuric acid.
- 1                    42.     A process according to claim 39 in which the acid comprises  
2     trifluoroacetic acid.
- 1                    43     A process according to claim 39 in which the acid comprises  
2     trifluoromethanesulfonic acid.
- 1                    44.     A process according to claim 27 in which the acetyl anhydride  
2     comprises acetyl sulfate.
- 1                    45.     A process according to claim 27 in which the acetyl anhydride  
2     comprises acetyl trifluoroacetate.
- 1                    46.     A process according to claim 27 in which the acetyl anhydride  
2     comprises acetyl trifluoromethanesulfonate.
- 1                    47.     A process according to claim 27 in which step (a) is conducted at a  
2     temperature of from about 10 to about 200 °C.
- 1                    48.     A process according to claim 27 in which the step (a) is conducted at a  
2     temperature of from about 60 to about 100 °C.
- 1                    49.     A process according to claim 27 further comprising recovering acetic  
2     acid from step (b).
- 1                    50.     A process according to claim 39 in which an acid corresponding to the  
2     acid used in step (a) is recovered from step (b), and said acid is recycled to step (a).
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- 2                    51.     A process for the production of an acetate ester comprising:
- 3                    (a) contacting methane and carbon dioxide in an anhydrous environment in the  
4     presence of effective amounts of a transition metal catalyst and a reaction promoter, and an  
5     acid anhydride compound, and optionally an acid, to produce a product comprising an acetyl  
6     anhydride; and

7 (b) reacting the product of step (a) with an alcohol to produce a product comprising  
8 an acetate ester.

1 52. A process according to claim 51, further comprising  
2 (c) recovering the acetate ester from the product of step (b).

1 53. A process according to claim 51 in which the product of step (b)  
2 further comprises acetic acid, said process further comprising:  
3 (c) recovering acetic acid from the product of step (b).

4 54. A compound having the formula  $\text{CH}_3\text{C}(\text{O})\text{-O-SO}_2\text{CF}_3$ .